TYPICAL SYNOPTIC SITUATIONS FOR THUNDERSTORMY DAYS OBSERVED OVER THE MAJORITY OF POLAND, AND WITH THE HIGHEST PROBABILITY OF THUNDERSTORMS OCCURRENCE IN THE COUNTRY

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ABSTRACT:
In the present study, we have performed an analysis of synoptic situations in thunderstorm days, during which the thunderstorm phenomenon was noted at at least 80% of meteorological stations located in Poland or at which the probability of an occurrence of days with this phenomenon was the highest and whose frequency explains the occurrence of days with thunderstorms on the highest level. The analysis of synoptic maps from the period 1951-2000 made the isolation of two different synoptic situations characteristic for days with thunderstorms occurring over the entire area of Poland possible. As well two synoptic situation with the highest probability of thunderstorms occurrence and which frequency explains the best the occurrence of days with thunderstorms have been distinguished

Key words: Poland, regression, probability, days with thunderstorm, atmospheric circulation

RESUMEN
En este estudio realizamos un análisis de las situaciones sinopticas en dias de tormenta, definidas como aquellas que aparecen en al menos el 80% de los observatorios meteorológicos polacos o en que la probabilidad de un acontecimiento de días con este fenómeno era la más alta y cuya frecuencia explica el acontecimiento de días con tormentas al mayor nivel. El análisis de mapas sinópticos a partir del período 1951-2000 permitió el aislamiento de dos situaciones sinópticas características de días con tormentas que ocurren sobre el conjunto de Polonia. También se han identificado dos situación sinópticas con la mayor probabilidad de ocurrencia de tormentas y cuya frecuencia explica el mejor el acontecimiento de días con tormentas.

1. INTRODUCTION

The atmospheric circulation, observed on a synoptic scale, and atmospheric processes with a mezoscale coverage, are responsible for the occurrence of thunderstorm phenomena (BARNES and NEWTON, 1986). The said circulation processes, determining the transport of humidity and heat, also influence the intensity and duration of thunderstorm phenomena. Numerous authors occupied with storm activity have noted the strong connections of this activity with specific synoptic situations (BIELEC-BĄKOWSKA, 2003, BRAZDIL, 1998, CHANGNON, 1998, CHANGNON and CHANGNON, 2001, KOLENDOWICZ, 2006, WALKER, 1992).

In the present study, we have performed an analysis of synoptic situations in thunderstorm days, during which the thunderstorm phenomenon was noted at at least 80% of meteorological stations located in Poland or at which the probability of an occurrence of days with this phenomenon was the highest and which frequency explains the occurrence of days with thunderstorms on the highest level.

2. DATA AND METHODS

The paper is based on the data pertaining to the occurrence of days with thunderstorm in 53 Polish synoptic stations within the IMGW (The Institute of Meteorology and Water Management) network in the years 1951-2000 for the first aim of that study and in the years 1971-2000 for the second one (Fig.1).

In order to identify the synoptic situation characteristic for thunderstorm days daily weather maps as at 00 UTC hour in the years 1951-2000 have been used. The analysis of surface synoptic maps made the isolation of two different synoptic situations characteristic for days with thunderstorms over the entire area of Poland possible. For the period 1971-2000 two synoptic situations with the highest probability of thunderstorms occurrence and whose frequency explains the best the occurrence of days with thunderstorms have been distinguished.

When examining the interdependence between the frequency of occurrence of days with thunderstorms and the types of synoptic situations developed hereunder, usage was made of probability of their occurrence in each type and Spearman's rank correlation coefficient. When attempting a quantitative designation of the influence of the abovementioned synoptic situation and air temperature and humidity on the occurrence of days with storms, use was made of the following logistic regression formula:

$y = 1/(1+\exp(a_0+a_1x_1+a_2x_1^2))$,

where a_0, a_1, a_2 and a_3 a_4 are estimated parameters.

The application of the regression made it possible to determine the dependence of occurrence of a day with a storm on the basis of the number of days with the analysed synoptic situation (x_1) in individual pentads of the year.

3. RESULTS AND CONCLUSIONS

Most frequently – i.e. in 20 days - thunderstorms occurred during the passage over the territory of Poland of a cold or occluded atmospheric front (or of a group of fronts, with a warm front preceding the cold front) from the north-west, the west, or the south-west. A distinct low pressure centre, with which the system of fronts is connected, is usually located over Iceland, the North Sea or northern Germany, and moves in a north-easterly direction. The approaching atmospheric front may also be connected with the low pressure system located above the Norwegian Sea, Scandinavia, or the Baltic. Generally, the speed of atmospheric fronts in the synoptic situation is high and the warm, cold and occluded fronts all move across the area of Poland within twenty four hours. An example of this synoptic situation is presented in Figures 3 and 4.

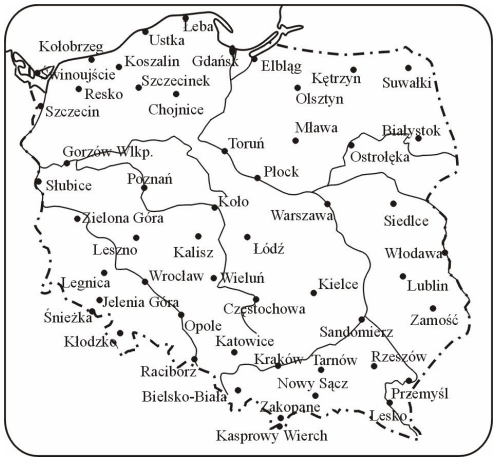

Fig. 1: Location of weather stations

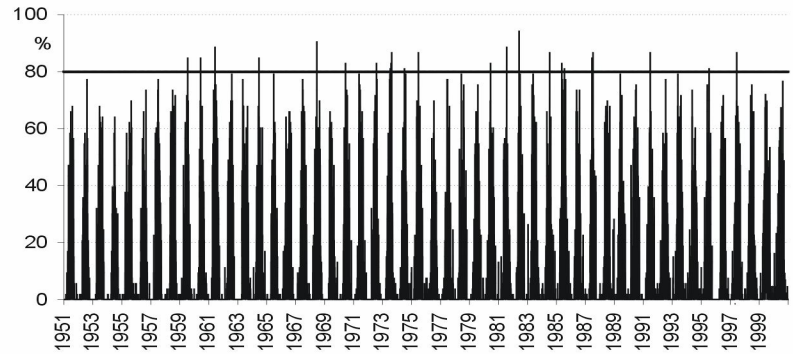

Fig.2: Percentage of weather stations in Poland where the thunderstorms occurred in days of the period 1951-2000 with marked 80% line

Less frequently- i.e. in 7 days - thunderstorms occurred at at least 80% of the stations in the territory of Poland as atmospheric fronts connected with a local low pressure system, the centre of which moves from the north-west to the north-east, directly above Western and Central Europe, including Poland. During this time, Europe experienced increased pressure with local centres of pressure lows and highs (Fig.5-6).

The probability of an occurrence of thunderstorm days at the selected synoptic situation is given in Table 1. The probability of an occurrence of a day with thunderstorm in synoptic situation S1 amounts to 15% and an occurrence of thunderstorms at at least 80% meteorological station in this situation is much less and reaches only 3,3%, whereas the situation S2 is characterised subsequently by 9% and 1%.

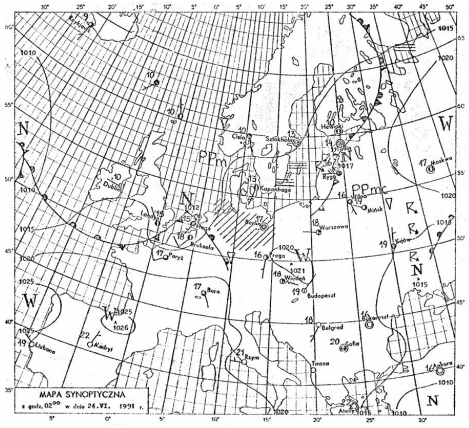

Fig.3 The synoptic map for 00 UTC on 24.VI.1991 (according to *Codzienny Biuetyn Meteorologiczny IMGW*)

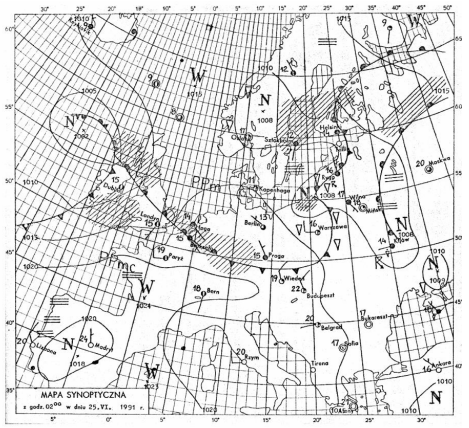

Fig.4 The synoptic map for 00 UTC on 25.VI.1991 (according to *Codzienny Biuetyn Meteorologiczny IMGW*)

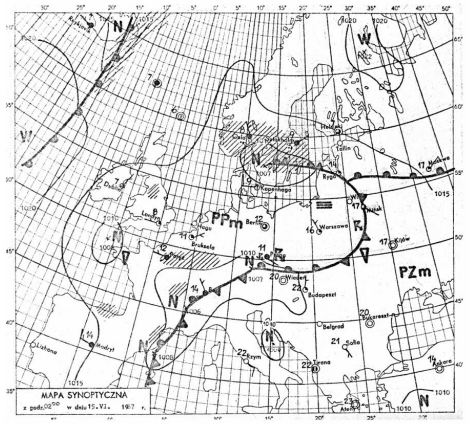

Fig.5 The synoptic map for 00 UTC on 15.VI.1987 (according to *Codzienny Biuetyn Meteorologiczny IMGW*)

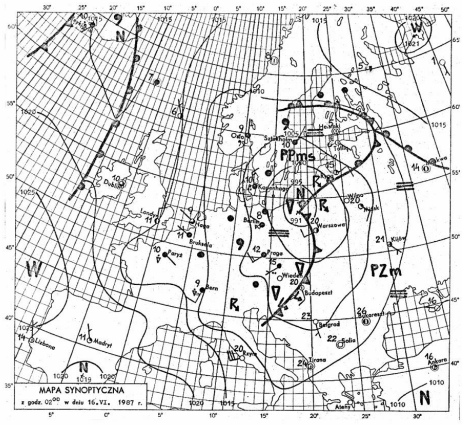

Fig.6 The synoptic map for 00 UTC on 16.VI.1987 (according to *Codzienny Biuetyn Meteorologiczny IMGW*)

In the second part of the study two very similar synoptic situations have been distinguished. The first one (S1A) where a cold front or system of atmospheric fronts moves into position above Poland from a northwesterly, westerly or south-westerly direction.

The second one (S2) – the same situation like the second one in the first part of the study (with the low pressure centre moving over territory of Poland). The values of the probability of an occurrence of a day with thunderstorm in specific types of synoptic situation, values of Spearman's correlation coefficient and percentage of explanation of the dependency of the days with thunderstorm frequency upon the days with distinguished synoptic situation frequency were given in tables 2 and 3. The probability of an occurrence of a day with thunderstorm in situation S1A exceeds 21%, whereas in situation S2 reaches almost 15%.
The frequency of days with situation S1A explains the occurrence of day with thunderstorm in more than 70% and for situation S2 the result amounts to more than 50%.

Synoptic situation	A (%)	B (%)
1	15,0	3,3
2	9,0	1,0

Table 1: PROBABILITY OF OCCURRENCE OF THUNDERSTORM DAYS AT THE SELECTED SYNOPTIC SITUATION – A, PROBABILITY OF OCCURRENCE OF STORMS AT LEAST 80% OF METEOROLOGICAL STATIONS IN THE TERRITORY OF POLAND AT THE SELECTED SYNOPTIC SITUATIONS - B. 1 – SITUATION WITH AN ATMOSPHERIC FRONT FROM THE WESTERN SECTOR, 2 – SITUATION WITH A LOW PRESSURE SYSTEM AND ATMOSPHERIC FRONTS OVER THE TERRITORY OF POLAND. DATA FOR POLAND FROM THE YEARS 1951-2000

	S1	S2
p	21,3	14,7
c	**0,71**	**0,53**

Table 2: PROBABILITY (%) OF AN OCCURRENCE OF A DAY WITH THUNDERSTORM IN SPECIFIC TYPES OF SYNOPTIC SITUATION (S1, S2) –P, VALUES OF SPEARMAN'S CORRELATION COEFFICIENT PRESENTED FOR A SUM OF DAYS WITH SYNOPTIC SITUATION (S1, S2) AND A SUM OF DAYS WITH THUNDERSTORM DURING THIS SITUATION - C. BOLD FONTS MEAN CORRELATION COEFFICIENT STATISTICALLY SIGNIFICANT AT P 0,01 LEVEL.. DATA FROM THE PERIOD 1971-2000

	a_0	a_1	a_2	E
S1A	7,9160274	-218,356	3706,5672	72,0
S2	6,3353522	-23,63199	0,0999993	55,6

Table 3: A_0, A_1, A_2 - ESTIMATED PARAMETERS OF REGRESSION FUNCTION, E – PERCENTAGE EXPLANATION OF THE DEPENDENCY OF THE DAYS WITH THUNDERSTORM FREQUENCY UPON THE DAYS WITH DISTINGUISHED TYPE OF SYNOPTIC SITUATION FREQUENCY DURING THE YEAR. S1A, S2– DISTINGUISHED TYPES OF SYNOPTIC SITUATION. BOLD FONTS IN E COLUMN SIGNIFY STATISTICALLY SIGNIFICANT VALUES. DATA FOR MEAN YEAR FROM 1971-2000

The frequency of days with distinguished synoptic situations and days with thunderstorm occurring in these situation are shown in figures Fig. 7,8,9. Only the situation S1A is characterised by the increasing trend of number of days with that situation and days with thunderstorms in the period 1971-2000.

Fig. 7: The frequency of synoptic situation S1 and days with thunderstorm in that situation TS1. Data from 1971-2000

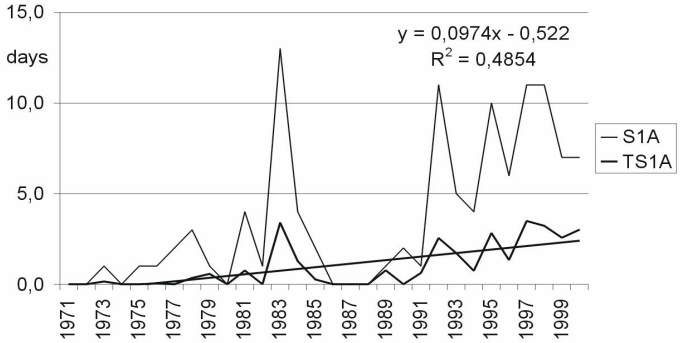

Fig. 8: The frequency of synoptic situation S1A and days with thunderstorm in that situation TS1A. Data from 1971-2000

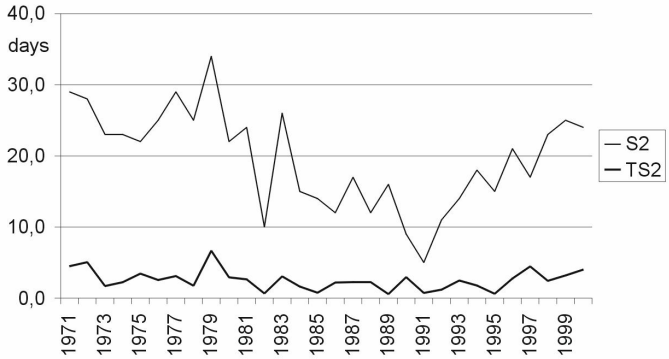

Fig. 9: The frequency of synoptic situation S2 and days with thunderstorm in that situation TS2. Data from 1971-2000

To recapitulate - we must state that the phenomenon of occurrence of thunderstorms in a given 24-hour period over the entire territory of the country is very infrequent. It concerns only during the summer period, which is characterised by the greatest frequency of thunderstorm occurrence. A day with this phenomenon occurs more or less once every two years (30 times during the researched 50-year period), most often in a synoptic situation with a rapidly moving cold atmospheric front from the western sector.

Based on the analysis of the correlations between atmospheric circulation and thunderstorm activity, carried out in storm areas and selected stations, it is possible to indicate Type 1 and Type 2 synoptic situations as the most conducive to the occurrence of stormy days. Both situation types are characterised by the highest probability of the occurrence of stormy days and the strongest correlation between their frequency and storm activity. In addition, forecasting the occurrence of stormy days on the basis of their frequency gives the best results compared with other synoptic situations (KOLENDOWICZ 2006). It has to be pointed out that Type 1 synoptic situation may be the cause of very violent storms not only in Poland, but also in Europe or the USA. This is reflected in the descriptions of individual cases of violent storms or their accompanying phenomena occurring over Europe (PIAGET 1976; COURVOISIER *at al.* 1979, KURZ, 1985, 1986; KOLENDOWICZ, 2003, 2005), and the results of the studies conducted by CHANGNON (1985, 2001), WALKNER (1992) and KOLENDOWICZ (1998, 2000,) pertaining to the analysis of a greater number of violent storms.

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